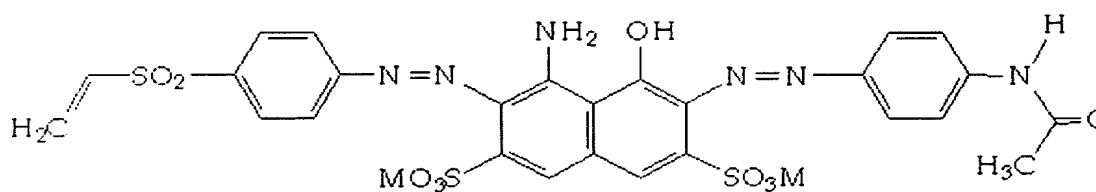


REACTIVE BLUE DYE CONTAINING A VINYL SULFONE GROUP

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to a reactive blue dye, and more particularly to a reactive blue dye represented by the following Formula 1, which is effective in black dyeing or printing of polyamide textiles, in particular, nylon fibre.



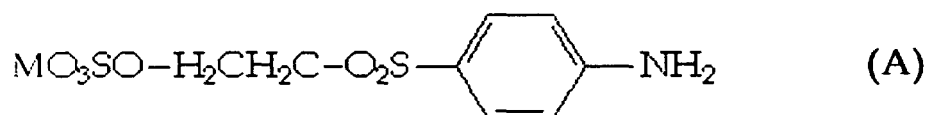
(1)

In Formula 1, M is a hydrogen atom or an alkali metal atom.

Description of the Related Art

Polyamide textiles, especially nylon fibre, have drawn much attention as a material for sportswear. In general, acid dyes are used for dyeing or printing of nylon fibre. However, when acid dyes are used for heavy color dyeing, the result of washing fastness becomes poor. Binders are often used to solve this problem, but they have drawbacks such as high cost and the deterioration of touch. Metal complex acid dyes used for high light fastness are undesirable in terms of environmental contamination related to heavy metals.

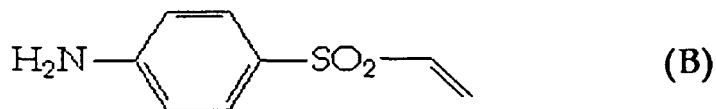
Japanese Patent Unexamined Publication No. Sho 43-15299 discloses an H-acid derived monofunctional disazo blue dye, which is obtained by diazotization of 4-aminophenyl-β-sulfatoethylsulfone represented by the following Formula A.



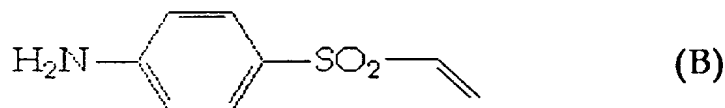
In Formula A, M is a hydrogen atom or an alkali metal atom.

Since the 4-aminophenyl-β-sulfatoethylsulfone substituted monofunctional blue dye is highly soluble in water, it is separated by salting out using a large amount of salts. In the process, wastewater contaminated with the concentrated dyes and salts is generated. When this dye is applied for dyeing, the dyeing efficiency is poor because of the low substantivity of the dye as well as the concentrated wastewater of the unfixed dyes is generated, thereby increasing the cost for the wastewater treatment. Also, due to the increasing demand on the use of liquefied dyes considering workers' health and automation of dyeing processes, a concentrated dye with low salt content is highly required.

As another blue dye, 4-aminophenyl vinylsulfone (Formula B) substituted dye is reported [Ho Jung Cho and D. M. Lewis, *Coloration Technology*, 2002, 116, 198-204].



less soluble to the water than the 4-aminophenyl- β -sulfatoethylsulfone (Formula A) substituted dye, it is more advantageous in salting out. In fact, because no salt is added during the separation of the 4-aminophenyl vinylsulfone (Formula B) the salt content of the wastewater can be reduced.



Moreover, since the obtained dye contains less salt, the salt content of the dyeing wastewater can be reduced, and the desalination process to obtain a liquefied dye becomes simpler.

SUMMARY OF THE INVENTION

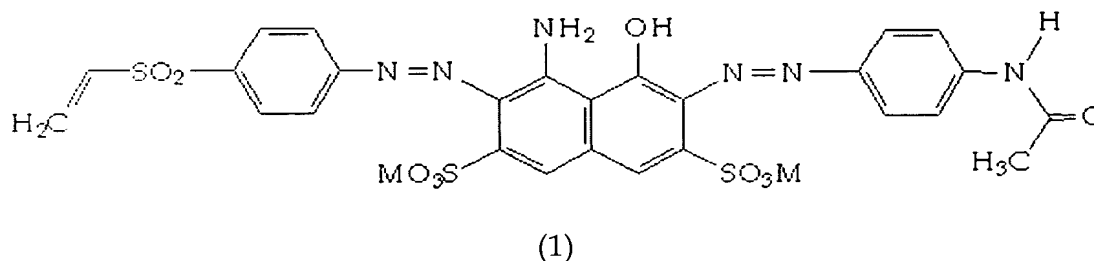
The present inventors tried to develop a new reactive dye for dyeing or printing of polyamide textiles, which has good substantivity, superior cleaning properties over unfixed dyes, and good color yield, reactivity, and fixing efficiency. As a result, we synthesized a novel reactive blue dye by introducing diazo phenyl radicals, particularly 4-aminophenyl vinylsulfone radical and 4-aminoacetanilide radical respectively, into H-acid.

Accordingly, an object of the present invention is to provide a novel reactive blue dye for heavy color dyeing, which satisfies the above-mentioned requirements and has superior light fastness and washing fastness, and a method for the preparation of the same.

DETAILED DESCRIPTION AND THE PREFERRED EMBODIMENTS

The present invention relates to a reactive blue dye represented by the

following Formula 1 and a method for the preparation of the same:



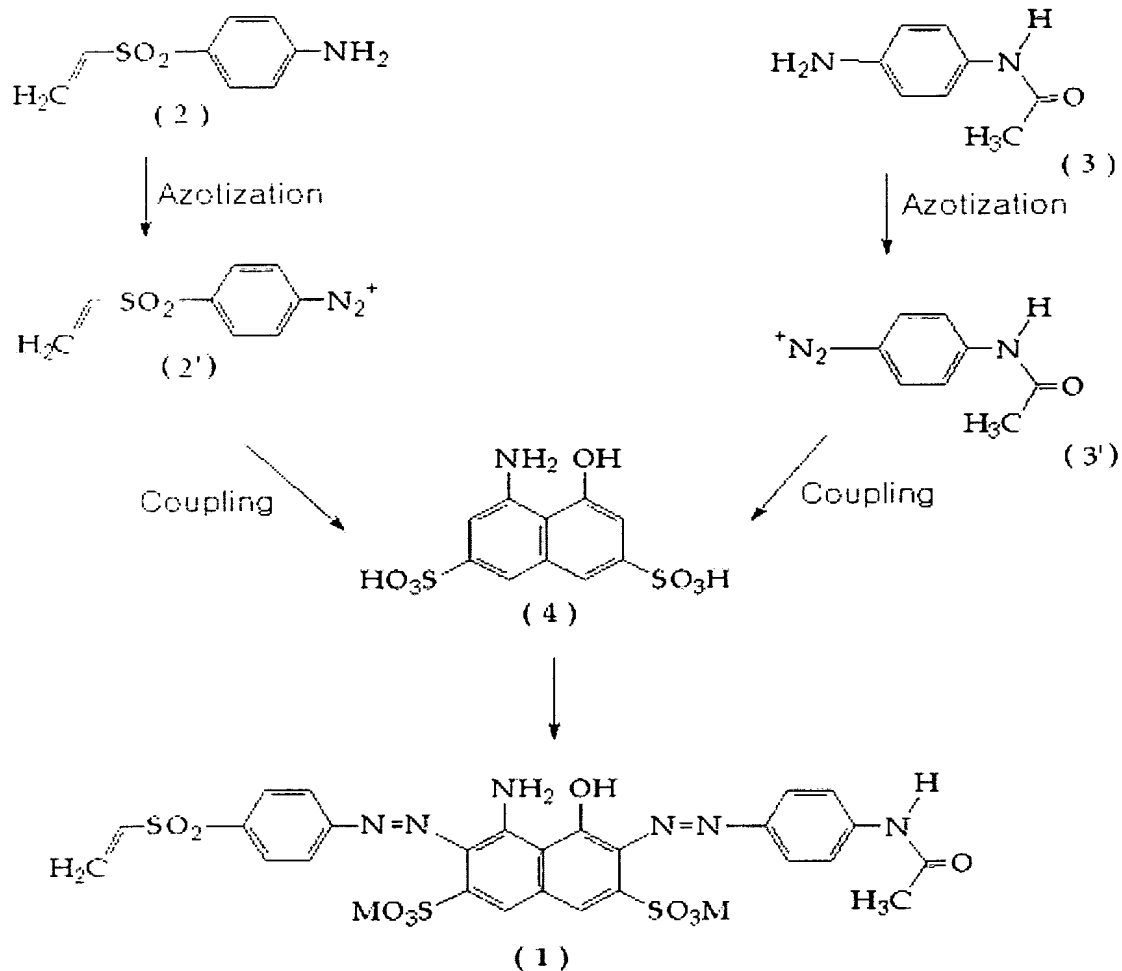
wherein M is a hydrogen atom or an alkali metal atom.

Hereunder is given a more detailed description of the present invention.

The present invention relates to a blue dye used for heavy color dyeing, especially for black dyeing of polyamide textiles, and more particularly to a reactive blue dye containing a functional group that can form a covalent bond with the amine group of polyamide textiles thus being effective in black dyeing or printing of polyamide textiles. The novel reactive blue dye of the present invention as shown in Formula 1 is derived from H-acid where 4-aminophenyl vinylsulfone and 4-aminoacetanilide are diazotized and coupled at C-2 and C-7, respectively.

The novel reactive blue dye of Formula 1 is prepared via the following Scheme 1:

Scheme 1



wherein M is a hydrogen atom or an alkali metal atom.

The preparation process of Scheme 1 comprises the following two steps:

a) a step of diazotization of 4-aminophenyl vinylsulfone represented by Formula 2 and the first coupling reaction with 1-naphthol-8-amino-3,6-disulfonic acid represented by Formula 4; and

b) a step of diazotization of 4-aminoacetanilide represented by Formula 3 and the second coupling reaction with the solution resulted from the step a).

The diazotization of the compounds represented by Formula 2 and Formula 3 is carried out in the temperature range of 0 to 5°C using sodium

nitrite.

The coupling reactions for the introduction of azo groups on the C-2 and C-7 of 1-naphthol-8-amino-3,6-disulfonic acid represented by Formula 4 are carried out in two stages. In the first coupling reaction of the diazo component represented by Formula 2', is achieved in the introduction of the 4-aminophenyl vinylsulfone group on the C-2 of 1-naphthol-8-amino-3,6-disulfonic acid represented by Formula 4 under the condition of 5 to 10°C and pH 1.0 to 2.0. Under the condition of 5 to 10°C and pH 6.5 to 7.5 the diazo component of 4-aminoacetanilide represented by Formula 3' is introduced onto the C-7 of 1-naphthol-8-amino-3,6-disulfonic acid represented by Formula 4, that is called the second coupling reaction. Through the first and the second coupling reactions is obtained a reactive blue dye of the present invention represented by Formula 1.

Hereinafter, the present invention is described specifically in Example, Comparative Example, and Experimental Example. However, the following Example is only for the understanding of the present invention, and the present invention is not limited by the following Example.

Example

(1) Diazotization of 4-aminophenyl vinylsulfone and first coupling reaction

To the 25mL of water in a beaker 1.85g (99%, 0.01 mol) of 4-aminophenyl vinylsulfone was added. While stirring, the suspension was cooled down to 5°C using an ice bath. To this mixture 3.67mL (3N, 0.011 mol) of NaNO₂ and 5g of ice were added. Then, 2.6mL of concentrated

hydrochloric acid was added to obtain a diazo component of 4-aminophenyl vinylsulfone. Excess HNO_2 was removed by adding a small amount of sulfamic acid.

To the 40mL of water in a beaker 3.9g (82%, 0.01 mol) of 1-naphthol-8-amino-3,6-disulfonic acid was added. This solution was neutralized (pH = 7) with 2.5mL of 4N NaOH aqueous solution and the 1-naphthol-8-amino-3,6-disulfonic acid was completely dissolved. This aqueous solution was transferred to a dropping funnel and was added dropwise to the diazo component aqueous solution of 4-aminophenyl vinylsulfone while keeping the temperature at 0 to 5°C to complete the first coupling reaction.

^1H -NMR (300MHz, DMSO-d_6) δ 10.62 (2H, br), 7.89 (4H, br), 7.52 (1H, s), 7.40~7.36 (1H, d, 12Hz), 7.18~7.10 (1H, dd, 9Hz, 6Hz), 6.36~6.30 (1H, d, 18Hz), 6.21~6.18 (1H, d, 9Hz)

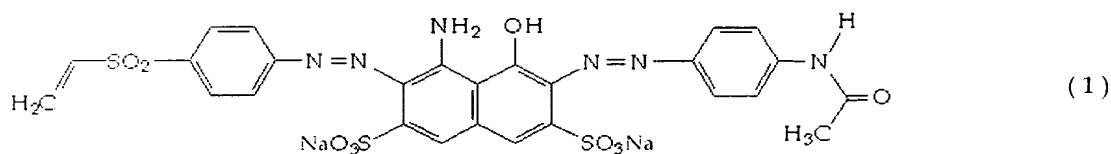
(2) Diazotization of 4-aminoacetanilide and the second coupling reaction

To the 25mL of water in a beaker 1.51g (99%, 0.01 mol) of 4-aminoacetanilide was added. While stirring, the suspension was cooled down to 5°C using an ice bath. To this suspension 3.67mL (3N, 0.011 mol) of NaNO_2 and 5g of ice were added. Then, 2.6mL of concentrated hydrochloric acid was added to obtain a diazo component of 4-aminoacetanilide. Excess HNO_2 was removed by adding a small amount of sulfamic acid.

To the solution where the first coupling reaction (1) was completed the aqueous diazo component solution of 4-aminoacetanilide was poured at once.

Then, 12mL of 20% Na₂CO₃ aqueous solution was added dropwise keeping the temperature at 5 to 10°C to complete the second coupling reaction while adjusting pH of the reaction mixture from 1.0-1.4 to 6.5. Completion of the reaction was followed by TLC. After warming up to the room temperature, the reaction mixture was filtered and the cake was dried to obtain the reactive blue dye of the present invention represented by the following Formula 1.

¹H-NMR (300MHz, DMSO-d₆) δ16.25 (1H, s), 10.72 (1H, s), 10.54 (1H, s), 10.15 (1H, s), 8.23~8.21 (2H, d, J = 6Hz), 7.98~7.96 (2H, d, J = 6Hz), 7.77~7.75 (2H, d, J = 6Hz), 7.44(1H, s), 7.35 (1H, s), 7.21~7.16 (1H, dd, J = 6Hz, 12Hz), 6.39~6.35 (1H, d, J = 12Hz), 6.23~6.21 (1H, d, J = 6Hz), 2.06 (3H, s)



Comparative Example

(1) Diazotization of 4-aminophenyl-β-sulfatoethylsulfone and first coupling reaction

To the 25mL of water in a beaker 2.96g (95%, 0.01 mol) of 4-aminophenyl-β-sulfatoethylsulfone was added. While stirring, the suspension was cooled down to 5°C using an ice bath. To this solution 3.67mL (3N, 0.011 mol) of NaNO₂ and 5g of ice were added. Then, 2.6mL of concentrated hydrochloric acid was added to obtain a diazo component of 4-aminophenyl-β-sulfato-ethylsulfone. Excess HNO₂ was removed by

adding a small amount of sulfamic acid.

To another beaker 3.9g (82%, 0.01 mol) of 1-naphthol-8-amino-3,6-disulfonic acid and 40mL of water were added. This solution was neutralized (pH = 7) with 2.5mL of 4N NaOH aqueous solution and the 1-naphthol-8-amino-3,6-disulfonic acid was completely dissolved. This aqueous solution was transferred to a dropping funnel and was added dropwise to the diazo component aqueous solution of 4-aminophenyl vinylsulfone while keeping the temperature at 0 to 5°C to complete the first coupling.

¹H-NMR (300MHz, DMSO-d₆) δ11.76 (1H, br), 10.58 (2H, br), 7.95~7.92 (4H, m), 7.52 (1H, s), 7.36 (1H, s, 1Hz), 7.27 (1H, br), 4.00~3.95 (2H, t, 6Hz, 9Hz), 3.68~3.63 (2H, t, 6Hz, 9Hz).

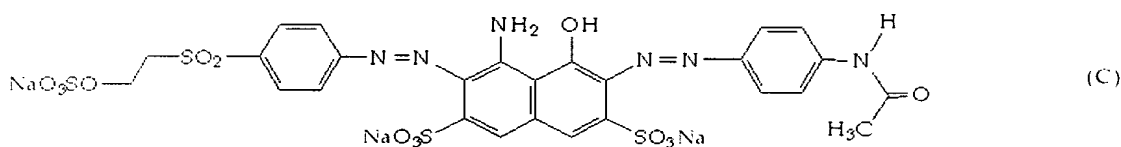
(2) Diazotization of 4-aminoacetanilide and the second coupling reaction

To the 25mL of water 1.51g (99%, 0.01 mol) of 4-aminoacetanilide was added. While stirring, the suspension was cooled down to 5°C using an ice bath. To this suspension 3.67mL (3N, 0.011 mol) of NaNO₂ and 5g of ice were added. Then, 2.6mL of concentrated hydrochloric acid was added to obtain a diazo component of 4-aminoacetanilide. Excess HNO₂ was removed by adding a small amount of sulfamic acid.

To the solution where the first coupling reaction was completed (1) the aqueous diazo component solution of 4-aminoacetanilide was added at once. Then, 14mL of 20% Na₂CO₃ aqueous solution was added dropwise keeping the temperature at 5 to 10°C to complete the second coupling reaction while

adjusting pH of the reaction mixture from 1.0-1.4 to 6.5. Completion of the reaction was followed by TLC. After the reaction was completed, a small amount of dilute hydrochloric acid was added to adjust pH of the reaction mixture to 4.5. Then, 15g of salt was slowly added for salting out. Then, the reaction solution was filtered and the cake was dried to obtain the reactive blue dye represented by the following Formula C.

¹H-NMR (300MHz, DMSO-d₆) δ16.25 (1H, s), 10.73 (1H, s), 10.56 (1H, s), 10.21 (1H, s), 8.23~8.21 (2H, d, J = 9Hz), 8.00~7.98 (2H, d, J = 9Hz), 7.78~7.75 (2H, d, J = 9Hz), 7.72~7.69 (2H, d, J = 9Hz), 7.47 (1H, s), 7.38 (1H, s), 4.01~3.97 (2H, t, J = 6Hz), 3.71~3.66 (2H, t, J = 6Hz), 2.06 (3H, s).



Experimental Example of Dyeing

The reactive blue dyes prepared in Example and Comparative Example were applied to nylon fibre by exhaustion dyeing method, and dyeing efficiency and light fastness were measured. The dyeing efficiency was calculated according to the following Equation 1:

Equation 1

$$\text{Dyeing efficiency (\%)} = (1 - A_1/A_0) \times 100$$

In Equation 1: A₀ is the light absorbance before dyeing; and A₁ is the

sum of the light absorbance after dyeing and washing.

Table 1

Classification		Example	Comparative Example
Dyeing efficiency (%)	1% o.w.f.	89.4	80.4
	3% o.w.f.	83.1	73.4
Washing fastness level ^{a)}	1% o.w.f.	5	5
	3% o.w.f.	5	5
Light fastness level ^{b)}	1% o.w.f.	4-5	3-4
	3% o.w.f.	5	4-5
a) Determined by KS K 030 A-4			
b) Determined by KS K 0218 direct lighting			

As shown in Table 1, the reactive blue dye of the present invention (Example), which has the 4-aminophenyl vinylsulfone group and the 4-aminoacetanilide group, showed much superior dyeing efficiency than the reactive blue dye (Comparative Example), which has the 4-aminophenyl- β -sulfatoethylsulfone group. And, while there was no difference in washing fastness, the reactive blue dye of the present invention showed improved light fastness.

The visible absorption spectrum of the reactive blue dye of the present invention ($\lambda_{\max} = 626.2\text{nm}$, $\varepsilon_{\text{mol/l}} = 5.6 \times 10^4$, $\varepsilon_{\text{g/l}} = 77.99$) was compared with that of the CI Reactive Black 5 ($\lambda_{\max} = 598.8\text{nm}$, $\varepsilon_{\text{mol/l}} = 3.7 \times 10^4$, $\varepsilon_{\text{g/l}} = 49.27$).

The λ_{\max} shifted toward the longer wavelength ($\Delta\lambda = 27.4\text{nm}$) and the light absorbance increased. Accordingly, when the reactive blue dye of the present invention is applied for dyeing or printing of nylon fibre, superior color yield, fixing efficiency, light fastness, and washing fastness can be obtained economically.

As explained in detail above, the reactive blue dye of the present invention has improved dyeing efficiency and washing fastness by introducing the 4-aminophenyl vinylsulfone group, which is capable of forming a covalent bonding with the amine group of nylon fibre. In addition, the water-solubility of the dye is lowered, and thus no salt is added during the separation process. Consequently, a highly pure dye can be obtained and the salt content of the wastewater can be reduced. While the present invention has been described in detail with reference to the preferred embodiments, those skilled in the art will appreciate that various modifications and substitutions can be made thereto without departing from the spirit and scope of the present invention as set forth in the appended claims.